

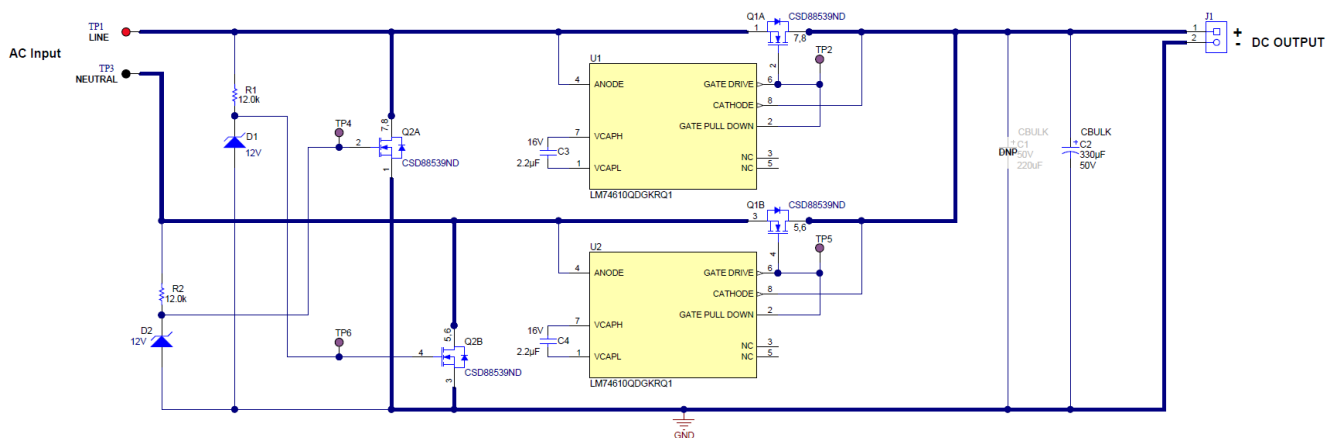
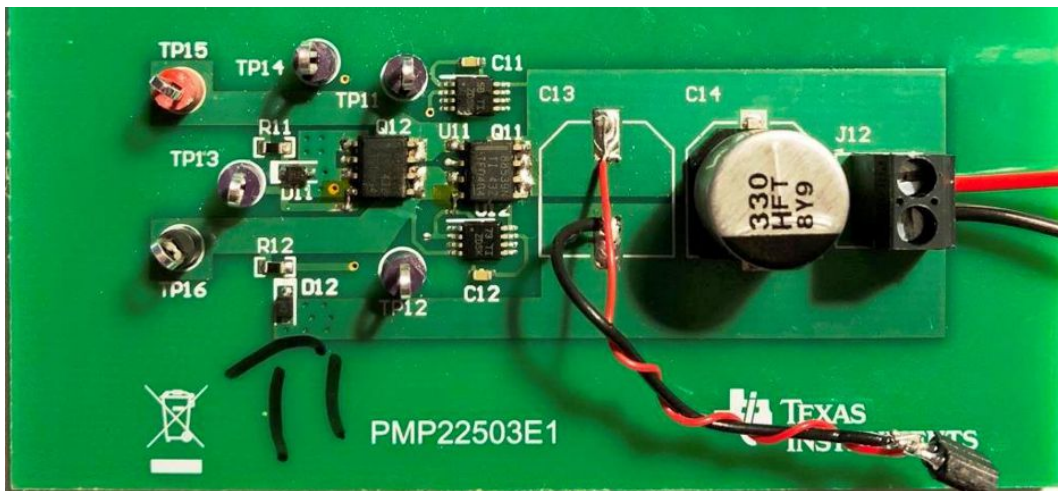
Test Report: PMP22504

12-V_{AC} to 28 V_{AC}, 7.5-W to 25-W Ideal Diode Full-bridge Rectifier Reference Design



Description

This reference design implements the *LM74610-Q1 Zero-I_Q Reverse-Polarity Protection Smart Diode Controller* to control the high-side rectifier MOSFETs for both line and neutral inputs of a 12-V_{AC} to 28-V_{AC} power supply. The design was tested at loads from 7.5-W to 25-W. The use of low R_{DS(on)} MOSFETs with ideal diode drivers eliminates the high losses found in standard diode rectifiers. Applications include video doorbells and smart thermostats that run off the 12-V or 24-V_{AC} transformer of a home or building.



1 Test Prerequisites

1.1 Voltage and Current Requirements

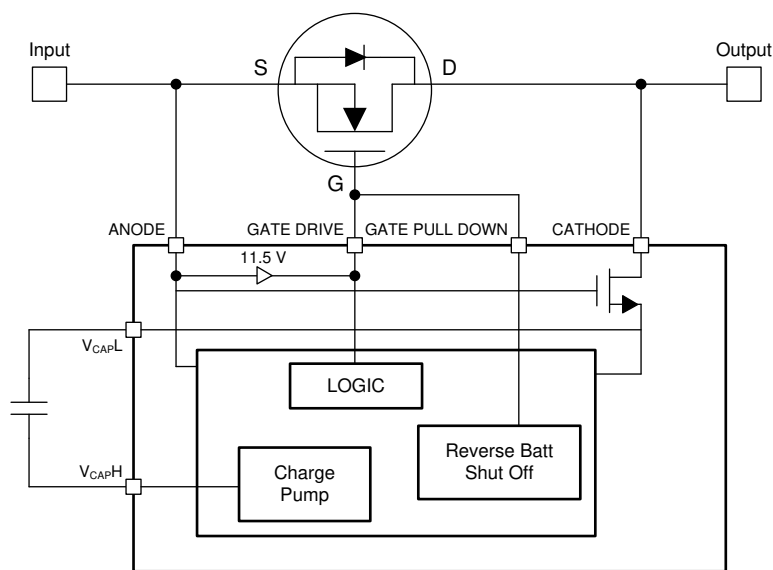
Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage	12- V_{AC} to 28 V_{AC}
Output Power	7.5-W to 25-W

2 Design Description

The LM74610-Q1 device is a controller device that can be used with an N-Channel MOSFET in a reverse polarity protection circuitry. It is designed to drive an external MOSFET to emulate an ideal diode rectifier when connected in series with a power source. A unique advantage of this scheme is that *it is not referenced to ground and thus has Zero I_Q* . The LM74610-Q1 controller provides a gate drive for an external N-Channel MOSFET and a fast response internal comparator to discharge the MOSFET gate in the event of reverse polarity. This fast pulldown feature limits the amount and duration of reverse current flow if opposite polarity is sensed.

The LM74610-Q1 controller does not have GND pin. During start up, it depends on the forward drop of the body diode to generate the charge pump voltage whenever a load is connected. The charge pump has a kind of hysteretic control, where it monitors charge pump (VCAP) voltage for high (VCAP-H) and low thresholds (VCAP-L). There will be a phase when gate drive is disabled when VCAP voltage reaches VCAP-L threshold and re-enabled when VCAP voltage is again charged to VCAP-H (see [Figure 2-1](#) and [Figure 2-2](#)). For additional information, see the [Feature Description](#) section of the [LM74610-Q1 Zero IQ Reverse Polarity Protection Smart Diode Controller Data Sheet](#).


Figure 2-1. LM74610-Q1 Functional Block Diagram

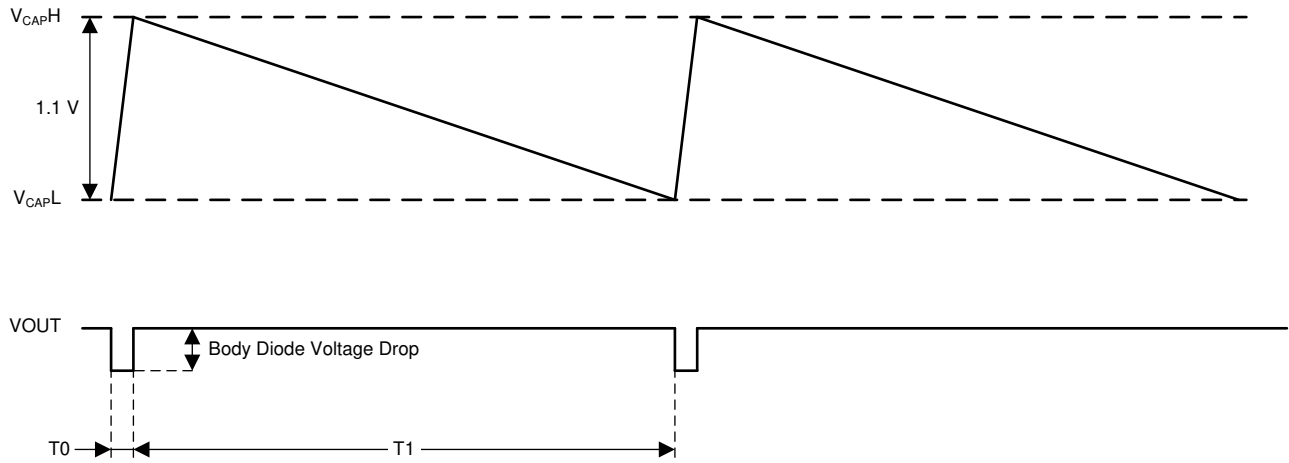


Figure 2-2. V_{CAP} Charging and Discarding by the Charge Pump

Figure 2-3 highlights the V_{gate} illustrating V_{CAP} discharging cycles.

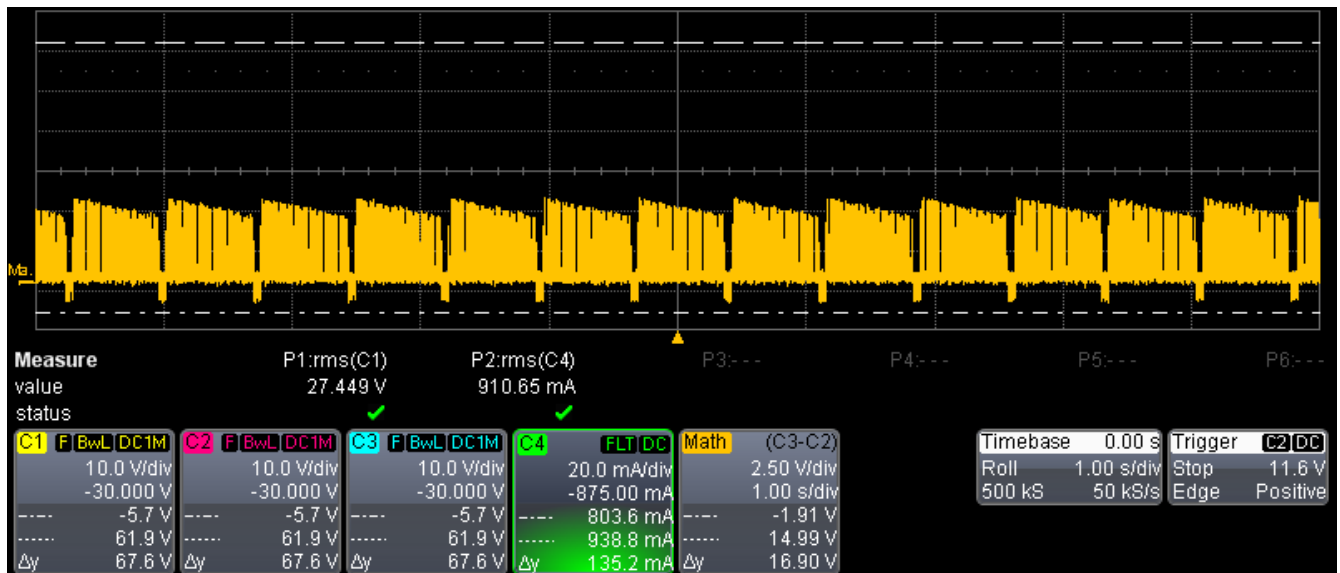


Figure 2-3. V_{gate} Illustrating V_{CAP} Discharging Cycles

3 Efficiency Data

Table 3-1 lists the efficiency data.

Table 3-1. Efficiency Data Table

$V_{AC(RMS)}$ (V)	Power In (W)	$V_{OUT(RMS)}$ (V)	$I_{OUT(RMS)}$ (A)	Power Out (W)	Efficiency	Power Loss (W)
12	7.65	11.67	0.642	7.49	97.9%	0.16
24	7.65	23.83	0.316	7.53	98.4%	0.12
28	7.74	27.85	0.269	7.49	96.8%	0.25
12	15.58	11.32	1.320	14.94	95.9%	0.64
24	15.26	23.68	0.633	14.99	98.2%	0.27
28	15.32	27.72	0.542	15.02	98.1%	0.30
12	26.65	10.83	2.310	25.02	93.9%	1.63
24	25.61	23.46	1.060	24.87	97.1%	0.74
28	25.82	27.54	0.908	25.01	96.8%	0.81

Figure 3-1 shows the LM74610-Q1 + TI CSD88539 FETs efficiency graph.

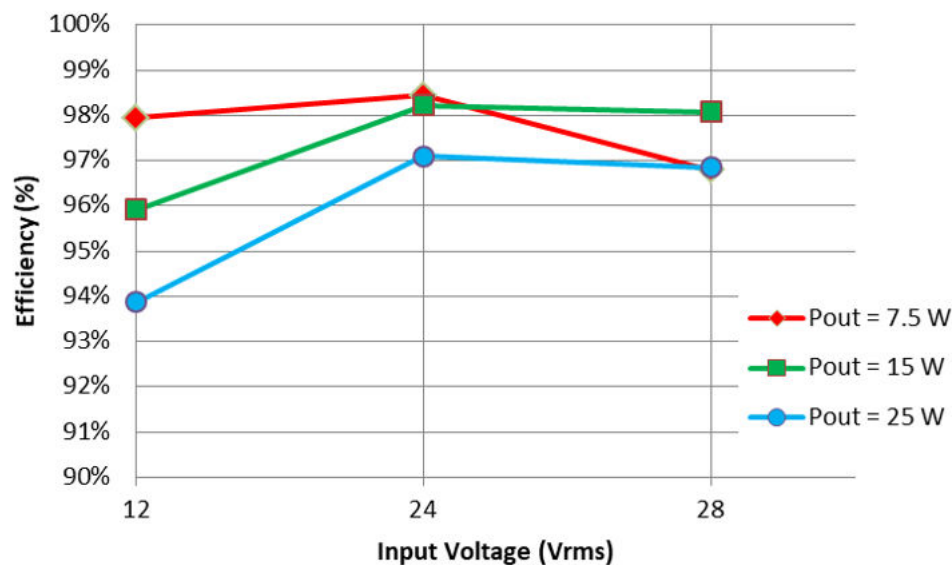
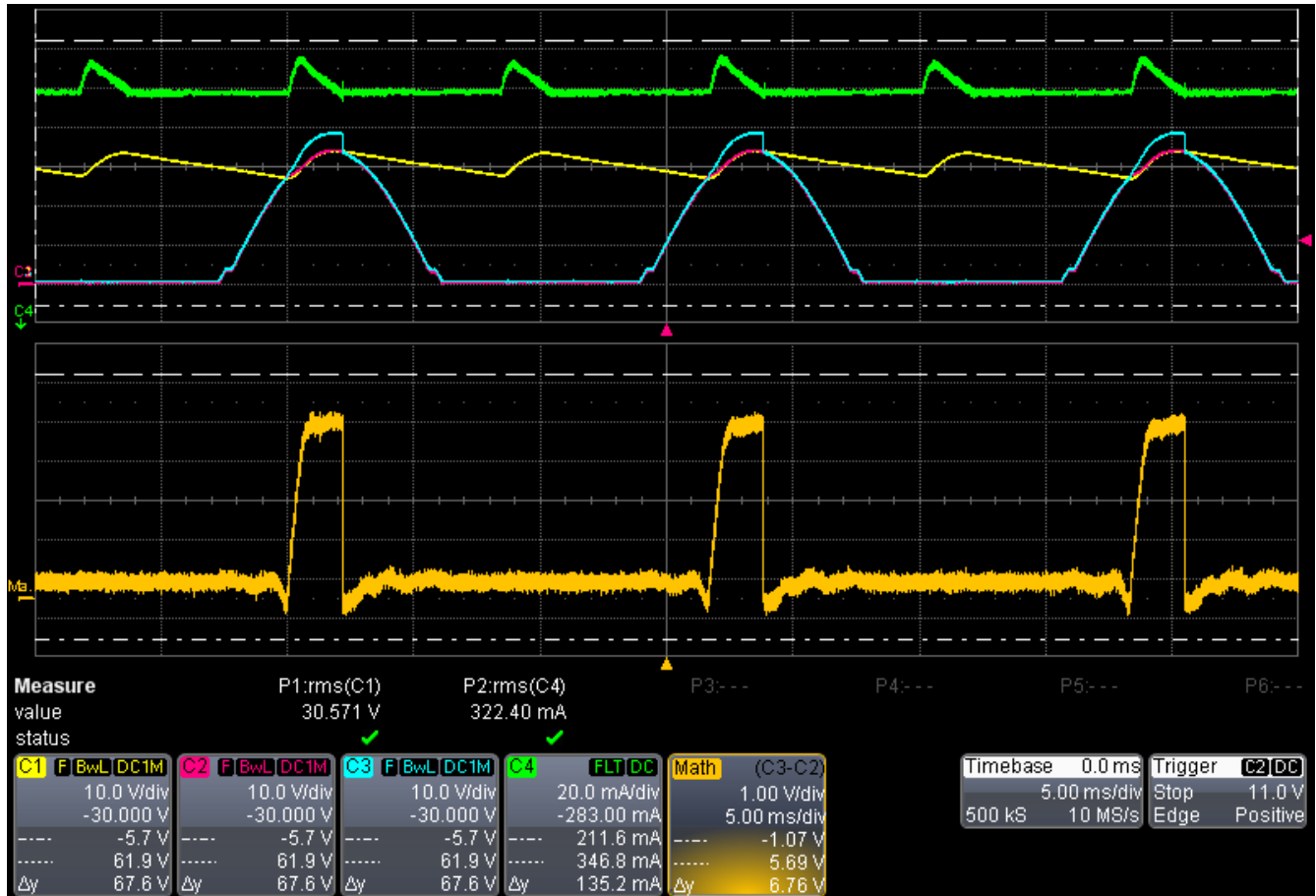


Figure 3-1. LM74610-Q1 + TI CSD88539 FETs

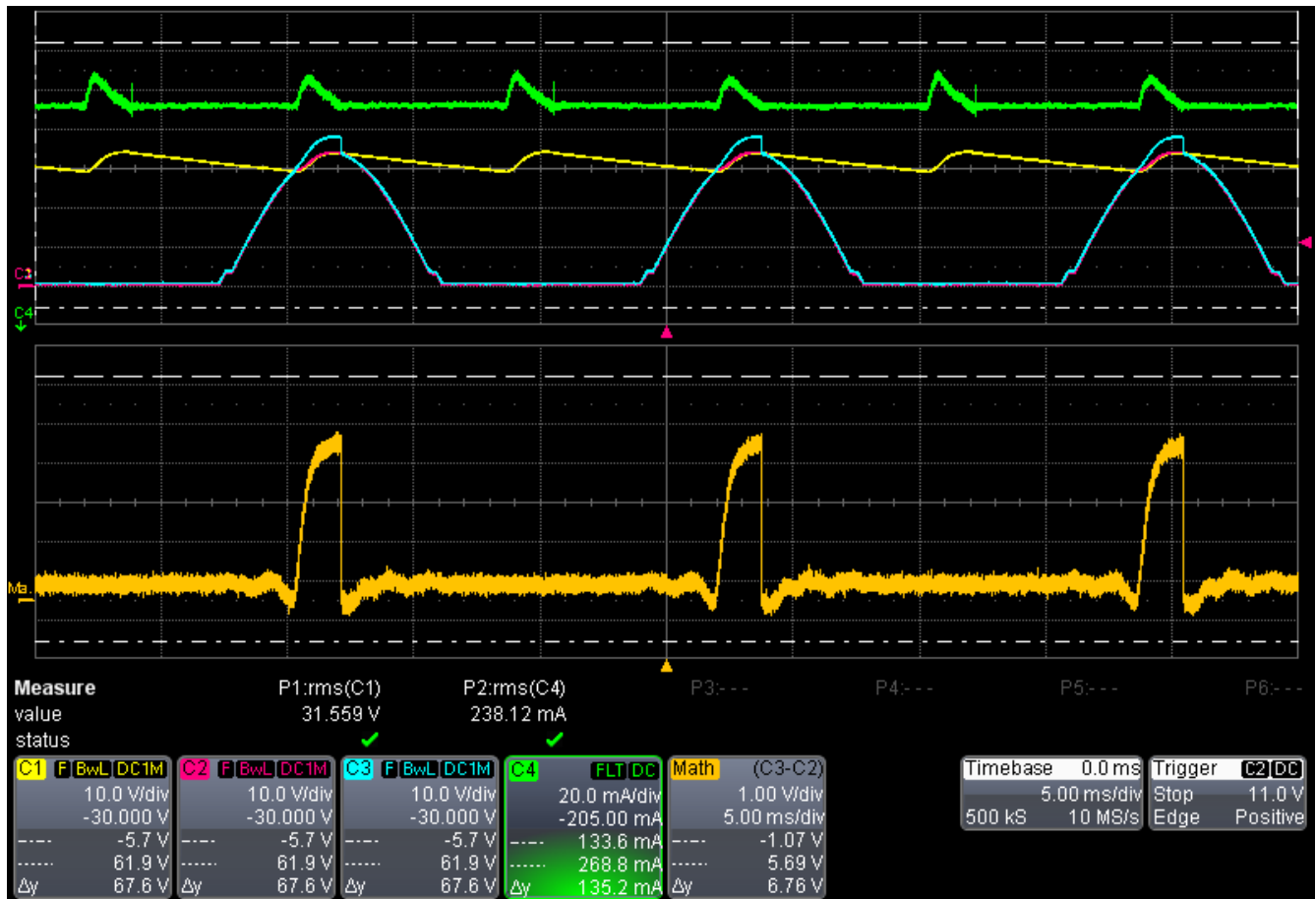
4 Scope Shots

Figure 4-1 through Figure 4-4 illustrate the PMP22504 scope shots.



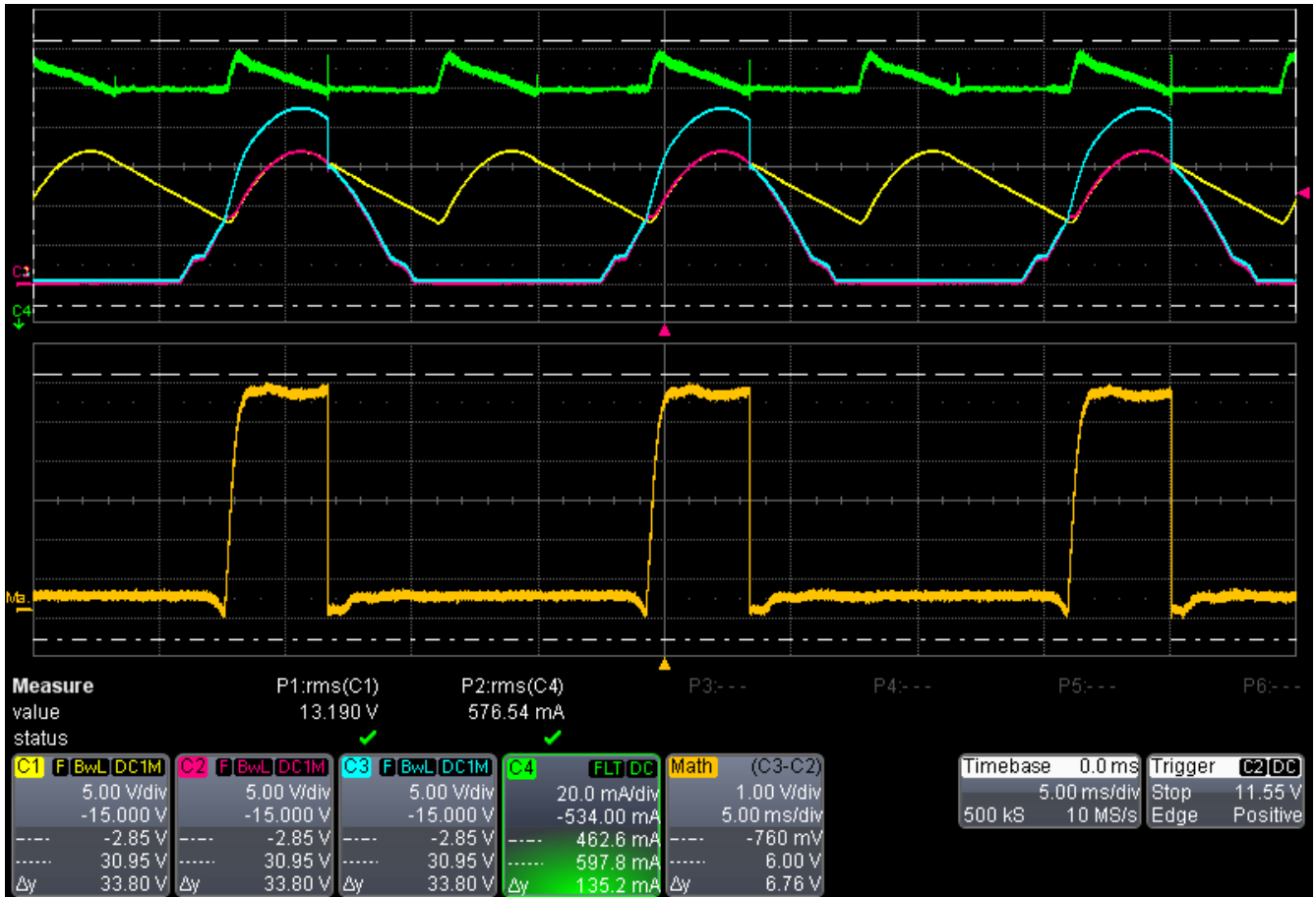
- Gold CH1: V_{OUT}
- Green CH4: I_{OUT}
- Magenta CH2: V_{IN} LINE
- Blue CH3: Active high-side FET V_{gate} measured
- Yellow MATH: V_{gate} calculated (CH3 – CH2)

Figure 4-1. 24-V_{IN} LINE Input, 10-W Output



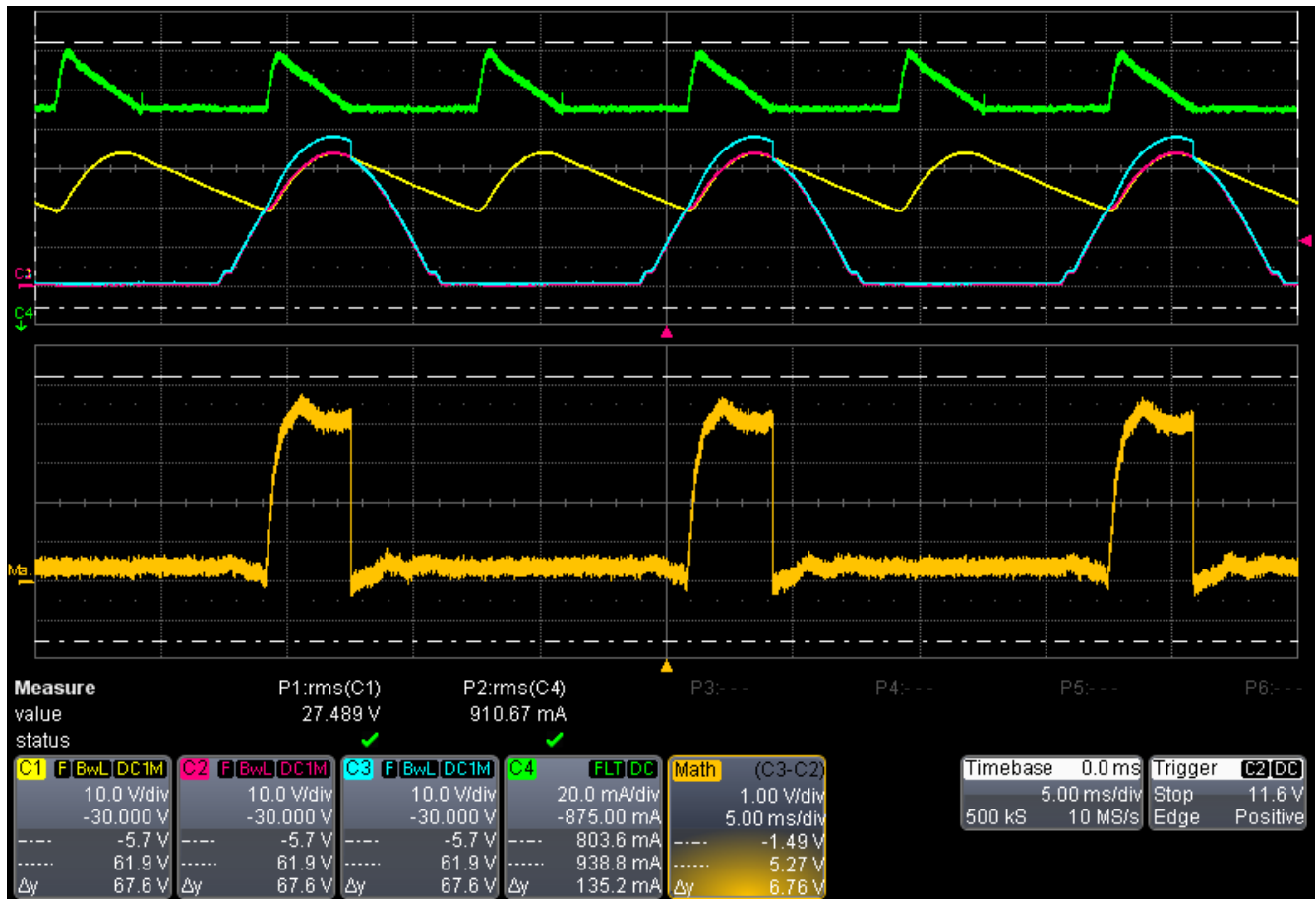
Gold CH1: V_{OUT}
 Green CH4: I_{OUT}
 Magenta CH2: $V_{IN LINE}$
 Blue CH3: Active high-side FET V_{gate} measured
 Yellow MATH: V_{gate} calculated (CH3 – CH2)

Figure 4-2. 24- V_{IN} LINE Input, 7.5-W Output



- Gold CH1: V_{OUT}
- Green CH4: I_{OUT}
- Magenta CH2: $V_{IN LINE}$
- Blue CH3: Active high-side FET V_{gate} measured
- Yellow MATH: V_{gate} calculated (CH3 – CH2)

Figure 4-3. 12- V_{IN} LINE Input, 7.5-W Output



Gold CH1: V_{OUT}
Green CH4: I_{OUT}
Magenta CH2: V_{IN} LINE
Blue CH3: Active high-side FET V_{gate} measured
Yellow MATH: V_{gate} calculated (CH3 – CH2)

Figure 4-4. 24- V_{IN} LINE Input, 25-W Output

5 Thermal Image

Figure 5-1 shows the PMP22504 thermal image.

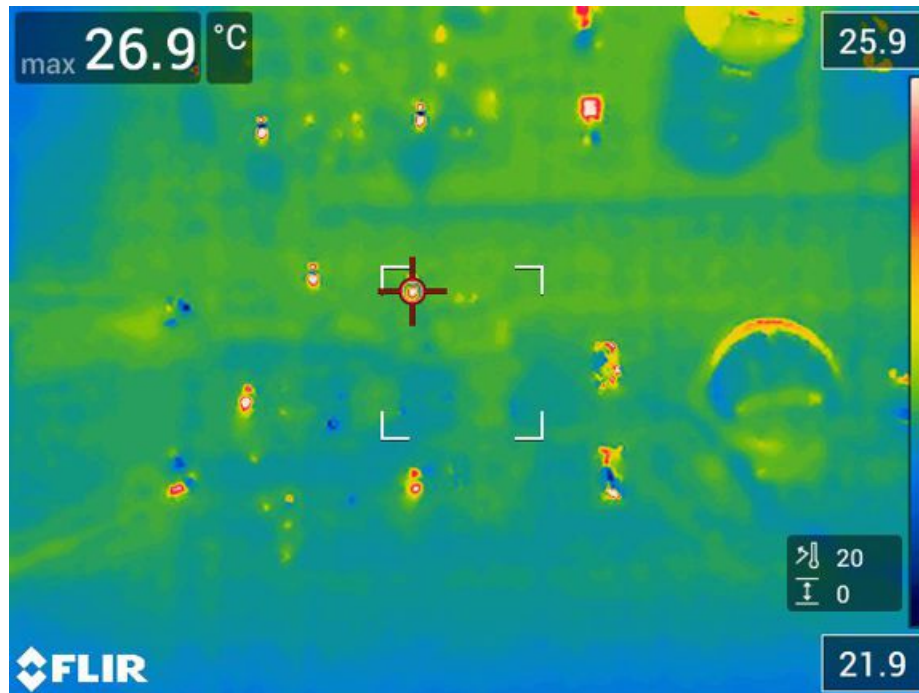


Figure 5-1. Thermal Image, $V_{IN} = 24 V_{AC}$, 15-W Output

6 Schematic and Assembly Diagram

Figure 6-1 shows the PMP22504 schematic and Figure 6-2 illustrates the assembly diagram.

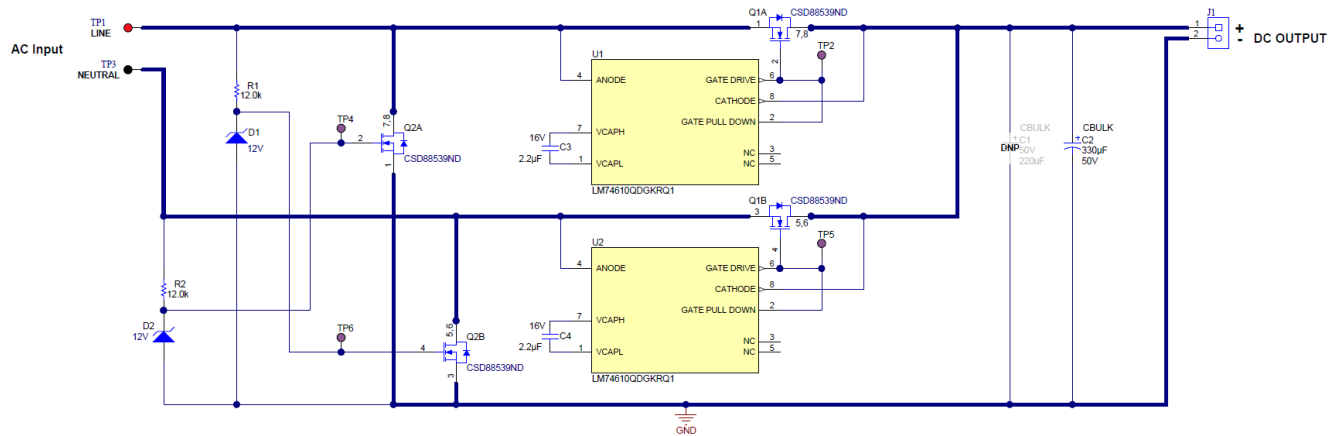


Figure 6-1. PMP22504 Schematic

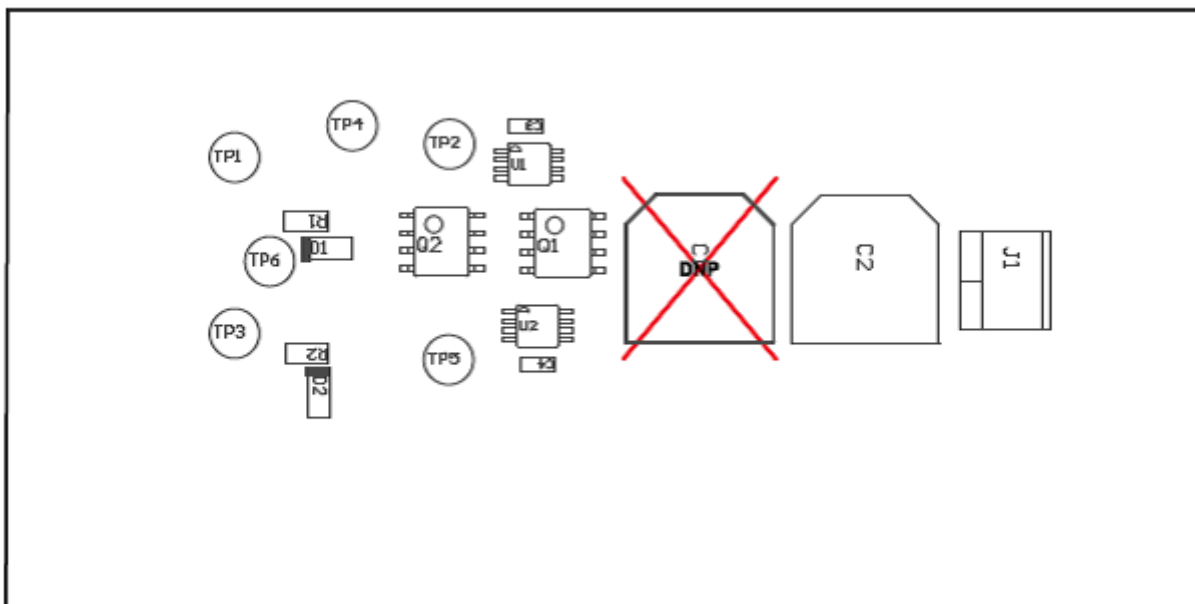


Figure 6-2. PMP22504 Assembly Diagram

7 Bill of Materials

Table 7-1 illustrates the PMP22504 revision E1 bill of materials.

Table 7-1. PMP22504 Revision E1 Bill of Materials

Item #	Designator	QTY	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB1	1		PMP22504	Any	Printed Circuit Board	
2	C2	1	330uF	EEE-FT1H331AP	Panasonic	CAP, AL, 330 μ F, 50 V, \pm 20%, 0.12 ohm, AEC-Q200 Grade 2, SMD	SMT Radial G
3	C3, C4	2	2.2uF	GRM188Z71C225KE43	MuRata	CAP, CERM, 2.2 uF, 16 V, \pm 10%, X7R, 0603	0603
4	D1, D2	2	12V	MMSZ5242BS-7-F	Diodes Inc.	Diode, Zener, 12 V, 200 mW, SOD-323	SOD-323
5	J1	1		ED555/2DS	On-Shore Technology	Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm
6	Q1, Q2	2	60V	CSD88539ND	Texas Instruments	MOSFET, 2-CH, N-CH, 60 V, 6.3 A, D0008A (SOIC-8)	D0008A
7	R1, R2	2	12.0k	RC0603FR-0712KL	Yageo	RES, 12.0 k, 1%, 0.1 W, 0603	0603
8	TP1	1		5010	Keystone	Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint
9	TP2, TP4, TP5, TP6	4		5129	Keystone	Test Point, Multipurpose, Purple, TH	Purple Multipurpose Testpoint
10	TP3	1		5011	Keystone	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint
11	U1, U2	2		LM74610QDGKRQ1	Texas Instruments	Zero Iq Reverse Polarity Protection Smart Diode Controller, DGK0008A (VSSOP-8)	DGK0008A
12	C1	0	220uF	EEE-FK1H221GP	Panasonic	CAP, AL, 220 uF, 50 V, \pm 20%, 0.18 ohm, AEC-Q200 Grade 2, SMD	SMT Radial G

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